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Byron Sylvester

CREEL RETURNS FROM HATCHERY TROUT IN JUNE LAKE, CALIFORNIA¹

By ELDEN H. VESTAL

*Bureau of Fish Conservation
California Division of Fish and Game*

Of major interest in the management of inland fisheries by the California Division of Fish and Game is evaluation of the results of the stocking program. This has become more important in recent years with the development in the State of certain hatchery facilities for increasing the size of fish planted.

To obtain yield data on several annual plants of sized trout was a major purpose in work undertaken at June Lake in Mono County of Eastern California. The project was begun in May, 1939, and carried on through 1942. Intensive use of the creel count, involving four separate plants of marked trout, has been the principal method.

June Lake was selected for the work for several reasons. Just a stone's throw from a state highway, it was easily accessible for the planting of sized fish, for intensive fishing, and for observation and study. It was large enough for tests on a major scale. Its fishing effort, centering around the three boat concessions at the south end leased by private individuals from the United States Forest Service, was comparatively easy to measure. It was virtually landlocked and, with its outlet screened, entirely confining to fish used in the study. Due to its lack of tributaries, it seemed probable that natural reproduction by rainbow would not succeed, and that the difficulty of measuring population increments from this source would not be encountered. Finally, judging from the appearance of fish produced by the lake in former years, it had a wealth of aquatic food and was capable of good productivity.

Acknowledgments

The project owes its inception and much of its worth to Alan C. Taft, Chief of the Bureau of Fish Conservation.

Grateful acknowledgment is due Robert C. Lewis, Foreman of Hot Creek State Hatchery, for rearing the rainbow trout used in the work and for help in marking and planting them.

The supervisors of the Mono and Inyo National forests, Messrs. D. M. Traugh and Roy Boothe, gave valuable cooperation by loaning CCC and ERA men in 1939 and 1940 to help in marking the trout and in recording the catch.

The operators and owners of the several boat landings on June Lake have contributed generously of their time and equipment to aid in the project. Frequently, when it was not possible for the writer or helpers to be present, the keeping of records at odd hours was continued by these persons, and I single out and express my sincere

¹ Submitted for publication, November, 1942.

thanks to Messrs. Wallace and Robert Gerth and C. A. Rakestraw of Camp Culver, George Conn and "Baldy" Farrington of June Lodge, Mr. and Mrs. Dewey Kirk of June Lodge Villa, and Mr. and Mrs. Russell E. Brinley of Boulder Camp, all of June Lake.

Not the least in acknowledgment is that due the hundreds of anglers at June Lake, without whose friendly cooperation the work would have been impossible.

Lastly, for critical help in summarization and compilation of the results of the creel work the writer is grateful to Mr. Brian Curtis, Supervising Fisheries Biologist of the Bureau of Fish Conservation.

Locale of the Census

June Lake is located in central Mono County, California, in the southern part of the Mono National Forest, at an elevation of 7,612 feet (Fig. 18). It is a typical glacial lake, the present character of



Photograph by Elden H. Vestal.

FIG. 18. June Lake, Mono County, California.

which is due to the last or Tioga glacial period.² It is roughly elliptical, with a shoreline that for the most part is rocky and steep. Over two-thirds of the lake is margined by rushes (*Scirpus acutus*). The surface area, as determined from a hydrographic map prepared by the Los Angeles City Department of Water and Power, is approximately 310 acres. The maximum depth on May 27, 1939, was 140 feet.

The lake has no inlet; its water supply is maintained by surface run-off and by a number of mostly marginal subsurface springs. June Lake had been low for a number of years, but in the spring of 1939, aided by the wet winter of 1937-38, the lake overflowed and a small outlet channel into the adjacent Gull Lake was created. This was screened temporarily by residents of June Lake and later permanently

² Blackwelder, Eliot. Pleistocene glaciation in the Sierra Nevada and Basin ranges. Bull. Geol. Soc. Am., Vol. 42, pp. 865-922. 1931.

by the California Division of Fish and Game in order to prevent resident fish from leaving June Lake.

Normally, June Lake is frozen during the period January to April. In summer, surface temperatures up to 69° F. have been noted.

Other features important in the production of fish include a wealth of mostly marginal and submarginal lake flora, a plankton abundant in variety and numbers of organisms, particularly cladocerans, and many kinds of marginal and bottom food organisms.

Observations have confirmed the expected failure of natural reproduction of rainbow trout in the lake, although the fish attempt to spawn along the wave-washed beach at the north end. Since the spring of 1939 a close vigil of spawning activities has been maintained, and marginal areas of the lake have been searched for naturally produced rainbow of the year. Not a single fingerling has been seen nor has there been any definite information received from old-timers of June Lake that survival from natural spawning by the rainbow ever occurred. On June 12, 1941, the writer excavated 620 naturally spawned rainbow trout eggs from three redds at a depth of 23 inches at the north end of the lake. Forty-eight of the eggs were clear and showed oil globules, the rest (572) were opaque or in various stages of opacity. None showed development. On the previous day (June 11th) a batch of eggs was spawned and artificially fertilized, then placed within a screen basket in gravel in a redd some 20 inches deep at the north end of the lake. On July 12th the eggs were removed, cleared in saturated salt solution and examined. No development was found in 135 eggs; 21 of the ova were attacked by fungus. At the same time 203 naturally spawned eggs were removed from redds nearby. No development was observed in the eggs after clearing in the salt solution. One egg was jet black, seven were gray, and the rest were white to cream color.

Fishes identified from June Lake to date have been the following:

- Rainbow trout (*Salmo gairdnerii*)
- Eastern brook trout (*Salvelinus fontinalis*)
- Loch Leven trout (*Salmo trutta*)³
- Lake chub (*Siphateles obesus*)
- Sand bar sucker (*Catostomus arenarius*)
- Three-spined stickleback (*Gasterosteus aculeatus*)

Fishes other than rainbow trout, chiefly eastern brook, enter the angler's creel, but altogether comprise much less than 1 per cent of the total catch. All fishes have been introduced.

Although thousands of sticklebacks are present in June Lake they apparently do not have any adverse effect on the present trout fishery; in fact, stomach samples at times have revealed the "pinfish" to form a good portion of the diet of rainbow trout over 10 inches long.

The presence of lake chubs and sandbar suckers in June Lake was revealed in gill net samples in April 1940. The net used was 5 feet deep and had a length of 125 feet, made up of five 25-foot sections graduated from $\frac{1}{2}$ to 2-inch mesh, bar measure. Its catches indicate

³One Loch Leven, 62.5 cm. long, was taken in a gill net in 1941; this is the only one known from June Lake in nine years.

the relative abundance of the principal fishes in June Lake, as shown in the following table.

TABLE 1.
Gill Net Catches in June Lake

<i>Dates</i>	<i>Number of Sets</i>	<i>Number of hours fished</i>	<i>Number of Fish Caught</i>					<i>Total</i>
			<i>Rainbow</i>	<i>Eastern Brook</i>	<i>Loch Lemon</i>	<i>Sandbar Suckers</i>	<i>Lake Chubs</i>	
Jan. 28 to Nov. 15, 1941__	33	576	160	3	1	61	7	232
April 18 to Sept. 4, 1942__	9	99	113	7	0	38	3	161

No spawning or young of the lake chubs has been observed by the writer. The suckers spawn annually in deep springs near the south end of the lake. No sucker under nine inches has been taken in the



Photograph by Elden H. Vestal.

FIG. 19. Fishing boats on June Lake, May 30, 1940.

gill net, and all but one have been females. No suckers have been found in trout stomachs.

In 1939 and 1940 the trout season at June Lake was open only on Sundays and holidays during May, and thereafter daily until October 31st. In 1941 the season was lengthened to include all of May. In 1942 it was shortened by the exclusion of October.

During the first two years the northern one-fifth of the lake was closed to angling because of egg-taking operations. This restriction was altered in 1941 to embrace only the period May 1st to June 30th, inclusive. In 1942 the entire lake was opened from the start of the trout season.

Besides the above restrictions placed by the Division of Fish and Game, the Mono National Forest has limited the number of boats that may be used on the lake at any single time to one hundred, of

which the three boat concessions are allowed 20 each, the tourists and residents a total of 40.

Yield from Fish Planted in June Lake

Planting Program

During the period here reported June Lake has been stocked annually with rainbow trout reared at Hot Creek State Hatchery and planted as early as possible in each season. The gradual increase in the average size of the trout at time of planting is shown below in Table 2; also the dual fin removals used on part of each allotment.

TABLE 2

Planting and Fish Marking Program Used in June Lake, 1939-1942

	1939	1940	1941	1942
Date of Planting-----	5-26-39	6-19-40	5-22-41	4-29-42
Number of Fish Planted-----	70,000	70,000	70,000	100,000
Number Marked-----	30,000	30,000	30,000	20,000
Fins Removed-----	Ad & LV	LV & RV	Ad & RV	Ad & LV
Average Size in				
Number per ounce-----	2.6	1.3	1.2	0.85
Inches-----	1 in.	5 in.	5 in.	6 in.

("Ad" = adipose fin; "LV" = left ventral; "RV" = right ventral.)

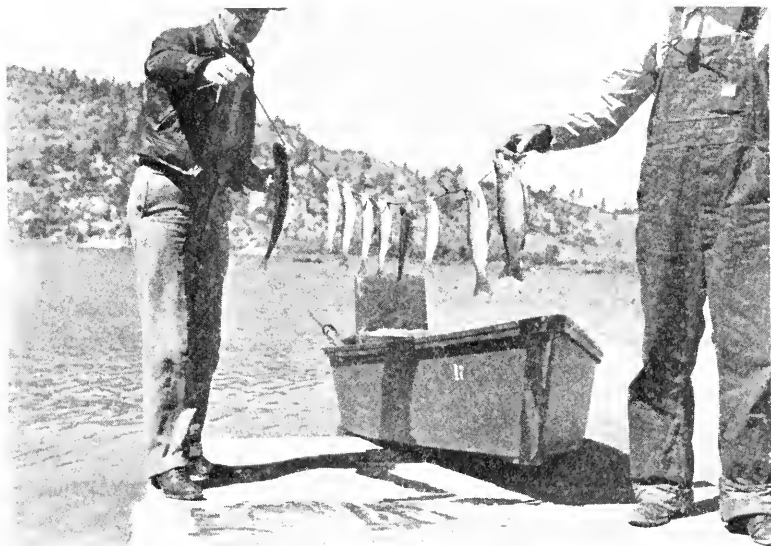
Yield in total numbers, per angler and per hour

From the best information available, June Lake during the period 1923 to 1926 was tops for fishing, two and three fish limits by weight being common. But decline set in and in the period 1930 to 1936 the fishery in June Lake apparently reached a low. The following year (1937), with the first plants of sized trout from Hot Creek State Hatchery, restoration of the fishery was begun. A rough estimate of fish caught in 1938 made by Mr. Charles Rakestraw at the lake indicated a total of 22,000 trout, and in the opinion of resort owners at June Lake, the output has steadily increased.

From 1939 to 1942 the creel census has been carried on by various methods. In 1939 records were kept daily at the boat landings by CCC boys under the supervision of the writer, with frequent checks to insure accuracy and uniformity. In 1940 the creel records were kept daily during May and June by ERA assistants loaned by the United States Forest Service, with supervision by the writer; for the remainder of the season the boat concessionaires and the writer kept the counts. During the season of 1941 the census was made mostly by the concessionaires; the writer gave frequent assistance, and periodically checked the counts by intensive samplings, paying especial attention to total numbers, species and year classes of fish caught in addition to number of anglers and number of hours fished. In 1942 the creel census was based entirely on intensive samplings of this nature carried on periodically by the writer at the three landings, covering 5,647 hours of fishing by 1,243 anglers for a catch of 3,536 trout.

These variations in the method have necessitated variations in the handling and interpretation of the figures. For the 1939 and 1940 seasons the difference between the total number of boats rented

and the total number of boats furnishing creel returns was taken to indicate the number of records missed in the count; this difference was then used to estimate the total number of fish caught for those seasons, the private boat catch being disregarded. In 1941 the ratio of private to rental boat use, based on counts of private and rental boats and anglers made periodically, provided the basis for estimation of the private angler catch; the latter, plus the total recorded rental boat catch, indicated the estimated total catch for the season. In 1942 the average catches recorded in the special samplings were applied separately to the estimated totals of private



Photograph by Elden H. Vestal.

FIG. 20. A typical catch of rainbow trout from June Lake.

and rental boat anglers (based on the concessionaires' records and on counts of private boats) to obtain the combined catch estimates.

As in most census work, difficulties have arisen from failure to include all data on some of the records, especially in the earlier years. Rather than discard these entirely such information as they do yield has been utilized, and they are referred to in Table 3 as "incomplete records." A further difficulty lies in the failure to obtain any records at all from certain anglers in 1941, when the boatmen were doing a large part of the work. About 20 per cent of the rentals in this year yielded no returns. To apply average catches to these would have been poor technique, inasmuch as many if not most of such failures were probably due to "zero" catches. They have, therefore, been disregarded entirely.

The different systems described above yielded results of varying reliability. The 1942 figures are thought to be highly reliable, 1941 slightly less so, while 1940 and 1939 are viewed with less confidence. All are summarized in Table 3.

TABLE 3

June Lake Creel Returns, 1939-1942

<i>Trout: recorded catch</i>	1939	1940	1941	1942
Complete records --	16,452	18,060	26,908	
Incomplete records --		1,416	1,863	
Sample only -----				3,536
Total recorded catch--	16,452	19,476	28,771	
<i>Anglers</i>				
Recorded rental boat anglers (angler days) from complete records only -----	4,620	6,299	8,701	
Recorded rental boat anglers sample only -----				1,246
Estimated unrecorded rental boat anglers -----			2,249	13,454
Estimated total rental boat anglers -----			10,950	14,700
Estimated private boat anglers--			3,502	5,130
Estimated total anglers-----			14,452	19,830
<i>Estimated Total Catch</i>				
Recorded rental boat catch-----	16,452	19,476	28,771	
Estimated rental boat catch-----				41,601
Estimated private boat catch-----			9,680	14,364
Estimated total catch-----	26,000	29,000	38,451*	55,965
Average hours per angler day-----	5.0 (est)	5.2	5.6	4.5
Average catch per angler (recorded) -----	3.1**	2.9	3.1*	2.8
Average catch per angler per hour (recorded) -----	0.60**	0.55	0.56*	0.62

* These starred 1941 figures do not include 2249 unrecorded rental boat anglers whose catch is almost certainly below average. Total 1941 catch is undoubtedly higher than the estimate of 38,451.

** From complete records for 52 days only.

The data do not include bait and fly fishing from shore, which form not over 2 per cent of the total fishing effort; consequently, the total numbers of fish caught were actually greater than those indicated. Nevertheless, the data reveal two significant facts:

1. The planting of sized trout in June Lake over a four-year period has resulted in a sustained yield in the face of heavy fishing.

2. The records indicate that the annual allotments have been such that a steady increase in the intensity of fishing has been anticipated. In other words, maintenance of the catch per angler per hour at over 0.5 has not indicated depletion of stock in the lake.

Yield in age-groups of fish planted

No accurate data are available for the age-group yield from the recorded catch in 1939, but field notes, measurements and examination of scales indicated that the majority of fish caught were fish planted that same year and that the minority of fish caught consisted largely of plantings of the previous year. These observations were corroborated

rated by the quantitative data shown in the summaries for 1940, 1941 and 1942 (see Table 4), in which plantings of the same season and of the previous season predominated in the catch in the order named.

TABLE 4

Proportional Representation of Age-Groups in June Lake Catches, from Complete Records (1942 figures derive from the catch samplings)

Age Group	I.		II.		III.		IV.	
	Number caught		Number caught		Number caught		Number caught	
	Actual	Per mille	Actual	Per mille	Actual	Per mille	Actual	Per mille
<i>Marked Rainbow</i>								
1939 Catch-----	3,139							
1940 Catch-----	3,071	608	1,977	392				
1941 Catch-----	5,453	715	1,825	239	357	46		
1942 Catch*-----	295	596	182	368	18	38		
<i>All Rainbow</i>								
1939 Catch-----								
1940 Catch-----	10,528	586	7,119	413	5	+	2	+
1941 Catch**-----								
1942 Catch-----	1,640	776	433	265	35	17	4	2

Notes:

* Lower percentage of marked fish in 1942 plant (see Table 2) distorts the per mille figures for 1942 catch of marked fish.

** Many unmarked fish were not assigned to age groups in 1941, hence 1941 figures for "all rainbow" are not available.

The year-class returns by month throughout the 1940 and 1942 seasons are summarized in Tables 5 and 6. During May fish planted the previous year predominate in the catches, to be outnumbered later in the season by fish of the year. The earlier appearance of fish of the year in 1942 than in 1940 is due to the earlier stocking date in the later year (Table 2). The increase in the percentage of the catch provided by fish of the year in 1942 is closely proportional to the increase in stocking in 1942 (100,000 against 70,000 in previous years).

TABLE 5

Year Class Returns by Month in 1940, from Complete Records Only

Year Class	1937		1938		1939		1940		Totals
	Number Caught	% of Catch	Number Caught	% of Catch	Number Caught	% of Catch	Number Caught	% of Catch	
May -----					2443	100.0			2443
June -----					3417	85.4	583	14.5	4000
July -----	1	+			837	25.6	2431	74.3	3269
August -----	1	+	1	+	531	12.0	3883	87.9	4416
September ---			2	+	136	5.1	2522	94.8	2660
October -----			2	0.1	55	4.7	1110	95.1	1167
Totals -----	2		5		7419		10,529		17,955
Averages -----		+		+		41.3		58.6	

TABLE 6

Year Class Returns by Month in 1942, from Special Sample at Gerth Landing Only

Year Class	1939		1940		1941		1942		Totals
	Number Caught	% of Catch	Number Caught	% of Catch	Number Caught	% of Catch	Number Caught	% of Catch	
May -----	3	+	32	6	338	62	175	32	540
June -----	1	+	3	+	67	8	807	92	878
July -----					17	4	388	96	405
August -----					6	4	160	96	166
September ---					5	4	110	96	115
Totals -----	4		35		433		1640		2112
Averages -----		0.2		1.7		20.5		77.6	

Survival of fish planted.

Seventy thousand rainbow trout were planted annually in 1939, 1940 and 1941. Considering the *recorded* total catch for the period 1939-1941 combined of 64,699 trout, the average annual catch was 21,566 fish. Then, if both planting and catch were stabilized, the

$$\frac{\text{Average catch}}{\text{Average plant}} = \text{survival to the creel,}$$

or

$$\frac{21,566}{70,000} = 30.7\% \text{ yield to the creel.}$$

Or, considering the *estimated* total catch for the period 1939-1941 combined of 93,450 trout, the average annual catch for the three-year period was 31,150 fish. Then,

$$\frac{31,150}{70,000} = 44.5\% \text{ yield to the creel indicated.}$$

If we consider the *estimated* 1941 catch of 38,451 against the plants for preceding years of 70,000 annually, then:

$$\frac{38,451}{70,000} = 55\% \text{ yield to the creel indicated.}$$

If we assume that 77.6% of the total estimated catch of 55,965 trout in 1942 are of the 1942 plant, as indicated by the special sample at Gerth Landing (Table 6), then the total catch of 1942 trout in 1942 would be approximately 43,000. Compared to the plant of 100,000, this indicates a 43% yield to the angler the first year, not counting the 1942 trout which remain to be caught in later years. If 1943 results are comparable to 1942, over one-fourth as many 1942 fish will be caught in 1943 as in 1942 (see Table 8), or approximately 11,000. This added to 43,000 caught in 1942 would give a catch for the two years of 54,000, or a yield to the angler of 54%.

A comparison of the ratios of marked fish planted to marked fish caught revealed the following discrepancy in the 1940 catch.

	Planted		Caught
1939	$\frac{30,000 \text{ marked}}{70,000 \text{ total}} = 42.8\%$		$\frac{2,083 \text{ marked}}{7,768 \text{ total}} = 26.8\%$
1940	$\frac{30,000 \text{ marked}}{70,000 \text{ total}} = 42.8\%$		$\frac{3,407 \text{ marked}}{11,592 \text{ total}} = 29.3\%$

The foregoing suggests the possibility that the marked fish suffered a higher mortality than the unmarked. That this is not the case, and that the true solution lies in failure of the census takers in 1940 to count all marked fish, is shown by the writer's own records in 1941 and 1942 set forth in Table 7.

TABLE 7

1941 Catch		Census Taker's Records		Writer's Records	
Catch:	1,825 marked 6,660 total	= 27.4%	Catch:	129 marked 245 total	= 52.6%
Catch:	5,453 marked 21,260 total	= 25.6%	Catch:	977 marked 2,392 total	= 40.8%
1942 Catch					
1941 plant:	20,000 marked 70,000 total	42.8%	(All records made by writer only)		Catch: 218 marked 508 total = 42.9%
1942 plant:	80,000 marked 160,000 total	20.0%			Catch: 542 marked 2,983 total = 18.2%

Yield gradient

As yet, data are not available for a complete yield gradient by age-groups of fish planted. However, a fair idea is obtained from an average yield per 1000 recorded angler hours of fishing in June Lake, in the following Table 8.

TABLE 8

Average yield by age-groups of fish in June Lake per 1000 recorded angler hours.
1942 figures based on special sample of 2112 fish (3652 hours) at Gerth Landing

	in 1939	in 1940	in 1941	in 1942
Yield of 1942 rainbow				450
Yield of 1941 rainbow			418	119
Yield of 1940 rainbow		331	130	10
Yield of 1939 rainbow	?	220	14	1
Totals		551	562	580

The increased yield of fish in their first year in 1942 over 1941 is ascribable to the increased number of fish stocked in 1942. The 1940 catch is inconsistent with succeeding years; this discrepancy can probably be ascribed to errors in assigning fish to year classes resulting from the fact that much of this work was done by the boatmen in 1940. The yield gradient shown by the 1940 year-class (331 per 1000 hours the first year, 130 the second year, 10 the third year) is, therefore, probably incorrect, and the gradient for the 1941 fish probably nearer the truth, especially as the catch of fish of the year is close to that shown for the 1942 plant. The true picture is probably something like this:

Hypothetical availability of 70,000 five-inch rainbow planted in May of any year, assuming that angling intensity remains close to the present level:

Catch per 1000 angling hours: 420 in year of planting
120 in second year
12 in third year
1 in fourth year

The above figures are portrayed graphically in Figure 21, which is in the nature of a survival curve.

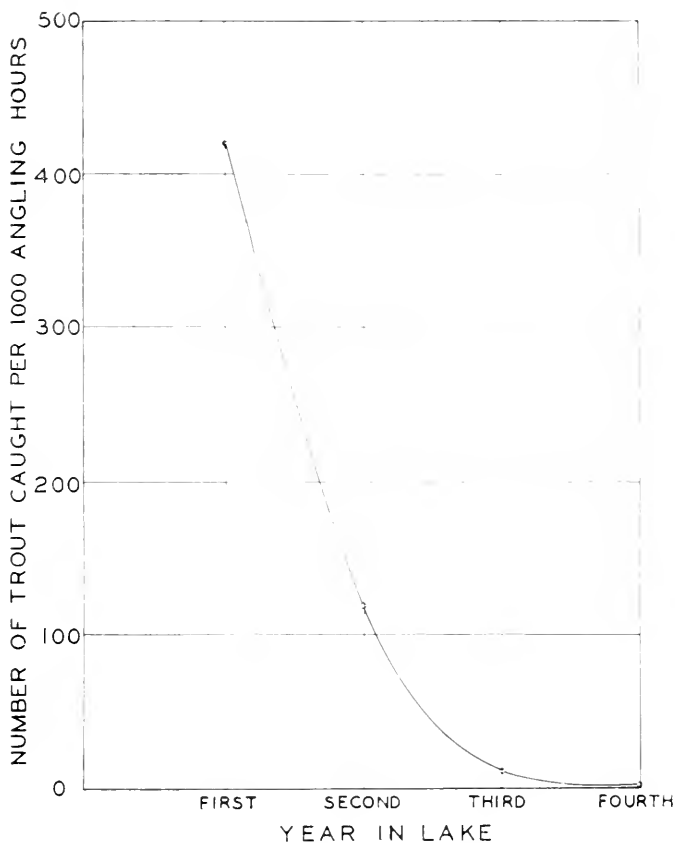


FIG. 21. Given a plant of 70,000 five-inch rainbow trout in June Lake in May of any year, this figure shows the hypothetical catch per 1,000 angling hours in their first, second, third and fourth years in the lake, under existing angling intensity.

Growth and Condition of Fish

Growth rate

The rate of growth in length of rainbow in June Lake is indicated in the summary below. At the intervals shown length measurements from the tip of the snout to the fork of the tail were taken in centimeters and later transposed to inches.

TABLE 9.
Rate of Growth in Marked 1939, 1940 and 1941 Rainbow
Trout Caught in Gill Nets in June Lake

	<i>Number of Specimens</i>	<i>Average Length in Inches, and Range</i>
<i>Marked trout of 1939 plant</i>		
At planting, May 1939.....	76	4.0 (2.4- 6.3)
At recovery, June 1940.....	50	12.3 (10.4-13.3)
At recovery, May 1941.....	4	14.5 (13.6-15.4)
Average gain in 24 months.....		10.5 inches
<i>Marked trout of 1940 plant</i>		
At planting, June 1940.....	50	4.6 (3.3- 6.0)
At recovery, June 1941.....	13	10.9 (9.7-11.9)
Average gain in 12 months.....		6.3 inches
<i>Marked trout of 1941 plant</i>		
At planting, May 22, 1941.....	59	4.6 (3.1- 5.5)
At recovery, April 19-May 19, 1942.....	10	11.6 (10.9-13.9)
Average gain in 12 months.....		7.0 inches

The rapid growth of the trout is one of the several indications of the productivity of June Lake. Rate of growth is most rapid during the first year and slows up considerably during the second.

Increases in weight of fish planted in June Lake are shown in the following records from marked fish:

TABLE 10
Weight Increase

	<i>Number of Specimens</i>	<i>Average Weight in Ounces, and Range</i>
Planted May 29, 1939.....	50	0.33 (0.07- 1.14)
Recovered May 7, 1941.....	3	21.65 (16.71-30.54)
Weight increase in nearly 24 months.....		21.3 ounces
Planted May 22, 1941.....	59	0.62 (0.3- 1.6)
Recovered April 19-May 19, 1942.....	13	11.4 (8.9-16.7)
Weight increase in nearly 12 months.....		10.8 ounces

Condition of fish

The condition of fish in June Lake is shown in the condition factors⁴ of marked trout recovered after one or two growing seasons. Average and range in condition factors, based on length of fish from tip of snout to fork of caudal fin, are given below in Table 11 for three age groups.

It will be noted that there appears to be a "normal" condition factor for June Lake rainbow of about 1.25. In the hatchery, just before planting, the CF is high—1.36 to 1.39. Within three months after planting this has declined to 1.22 or 1.23. Thereafter there appears to be a slight increase, the figure being 1.24 for the 1941 fish at end of first year, 1.25 for 1939 fish at end of second year.

⁴ Condition factor is an index of the weight-length relationship of the fish. The formula is

$$CF = \frac{\text{Weight in grams}}{(\text{Length in centimeters})^3} \times 100$$

TABLE 11

Changes in Condition Factor of Marked Rainbow Trout in June Lake

	<i>Planted</i>	<i>Recovered</i>	<i>Recovered</i>	<i>Recovered</i>	<i>Recovered</i>
Date	5 29 39	8 19 39	10 19 39		May, 1941
Number of Specimens	20	20	20		3
Condition Factor	1.38	1.22	1.26		1.25
Date	6 19 40			June, 1941	
Number of Specimens	50			13	
Condition Factor	1.36			1.24	
Date	5 25 41	8 10 41	10 12 41	4 19 42	19 42
Number of Specimens	43	10	12	10	10
Condition Factor	1.39	1.23	1.29	1.24	

Summary

1. Annual plants of rainbow trout of catchable size in June Lake from 1939 to 1942 have built up fishing from a low level, and have provided a sustained yield in the face of increasingly heavy fishing.

2. Over the four-year period, catches have averaged about 3 trout per angler-day, about 0.6 per angler-hour. In 1942 it is estimated that 19,830 anglers caught 55,965 trout. The majority of fish caught in any season were fish planted early the same season, while the minority catch was composed mainly of fish planted the previous year.

3. The ratio of average total recorded catch to average total plant for 1939, 1940 and 1941 indicated a *minimum* survival of fish to the creel of 30.7 per cent. A similar ratio for the estimated total catch for the same period indicated a minimum survival of fish to the creel of 44.5 per cent. Of the 1942 plant of 100,000 trout it is estimated that 43,000 were caught the same season, indicating a yield of 43 per cent the first year, and other figures suggest a probable yield of at least 54 per cent before this year-class is exhausted.

4. Marked fish planted in 1939 grew an average of 10.5 inches in length and 21.3 ounces in weight in nearly 24 months in the lake. Marked fish planted in 1940 grew an average of 6.3 inches in length in 12 months in the lake. Marked fish planted in 1941 grew an average of 7 inches in length in 12 months in the lake. Growth is greatest during the first year of life.

5. The average condition factor of marked fish planted in 1939 was 1.38; 24 months later the average condition factor was 1.25. The average condition factor of marked fish planted in 1941 was 1.39; 12 months later it was 1.24. High at planting, the condition factor declines during the first few months of adjustment in the lake to about 1.22; it then increases a small extent to approximately 1.25, a point apparently limited by the lake environment.

THE DISTRIBUTION OF MUSKRATS IN CALIFORNIA¹

By HOWARD TWINING and ARTHUR L. HENSLEY
Bureau of Game Conservation
California Division of Fish and Game

The muskrat is now California's most important fur bearer. In the last three trapping seasons, licensed trappers have taken more muskrats than all other fur-bearers combined. This has not been the case very long, however, for it was not until the winter of 1937-38 that trappers reported receiving more money for their muskrats than for any other species.

The upswing in the importance of muskrats started in 1933 when they commenced their first rapid spread beyond their native range. Muskrats were native in California along the Colorado River, and on the eastern border of California in the Walker and Truckee River watersheds, and in the tributaries of Honey Lake. It appears obvious that in prehistoric times they inhabited the shores of the great Lake Lahontan which once washed the eastern base of the Sierra Nevada, and with the disappearance of that lake the muskrats were left to continue their existence in any rivers or sinks that offered suitable habitat. It is a mystery why they were never able to cross the gap of not more than 15 miles between their present northern limit at Eagle Lake and the headwaters of the Pit River. Once they had gained the Pit, the whole of the Central Valley of California would have been open to their colonization.

Muskrats escaped from a fur farm into the Pit River in 1932 and rapidly spread into marshlands in much of Modoc and Shasta counties. Twenty pairs were introduced into Tule Lake, Siskiyou County in 1930 and thrived in this ideal marsh country to such an extent that in the winter of 1939-40 about 35,000 muskrats were caught in the lake and adjacent territory. Trappers transported muskrats from one marsh to another in northeastern California. A plant in Shasta Valley opened the entire Klamath River drainage to their colonization. Plants in Lake Earl, Del Norte County, in the Russian River, Sonoma County, and in the Feather River, Sierra County, opened new regions for their further spread.

In 1940 muskrats were established in almost every inhabitable part of northeastern California. New colonies were appearing all over the State. Even the Sacramento River was being invaded. The ranchers, once worried about this menace to their ditch banks and levees, were becoming reconciled to the new addition to the wildlife on their lands, and some were making welcome profits by leasing trapping rights to experienced trappers.

¹ Submitted for publication, December, 1942.

It was at this time that the California Division of Fish and Game organized a project to survey the fur resources of the State.² A part of this study included an extensive survey of muskrat distribution in California. This paper presents the results of the muskrat survey in which nearly every area populated by muskrats in the State was checked by the investigators. In the course of the general survey, certain problems that critically affect muskrats were disclosed and intensive work is continuing on these.

Originally there were only two kinds of muskrats in California—the Nevada muskrat (*Ondatra zibethica mergens*) of the eastern border of California, and the Colorado River muskrat or “sandrat” (*Ondatra z. bernardi*) of the Colorado River. The pelt of the Nevada muskrat is considered by fur buyers to be of average grade, ranking slightly lower in value than that of most other kinds of muskrats that have been imported into the northern part of the State. The sandrat is small and pale, bringing about one-third the price of an average northern muskrat.

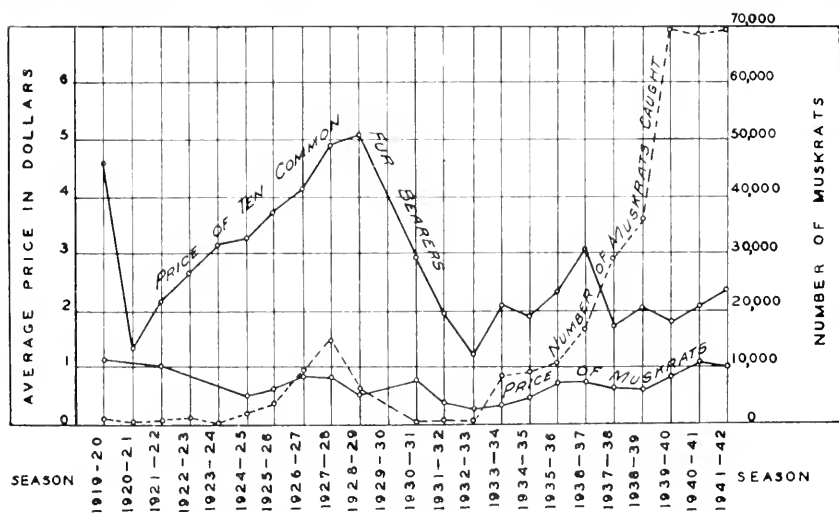


FIG. 22. Number of muskrats reported as caught in the past 23 years in California and average prices received for 10 common fur-bearers and for muskrat.

These two kinds made up the bulk of the catch, until the start of the spectacular increase in numbers of introduced muskrats brought in from outside the State.

In Fig. 22 the average prices received for muskrats are compared with the annual catches of muskrats for the past 20 years. The average prices quoted here are not very significant for they depend upon the proportion of less valuable sandrats in the catch. Consequently, the average prices received for a combination of the 10 commonest fur-bearers in the State has been added to indicate the general fluctuation of fur prices.

Several facts can be learned from this chart. Each year before the season starts in California thousands of trappers watch the early

² Federal Aid in Wildlife Restoration, Project California 5R., A Survey of the Fur Resources of the State of California.

quotations for fur prices. If quotations are high, the trapper will put out a line; if not, he will usually seek other employment for the three and one-half months trapping season. Between 1926 and 1928 prices were high and more trappers were active, so the muskrat catch increased. Records show that the catch of all other kinds of furbearers was high at this time too. It was undoubtedly this rise in price

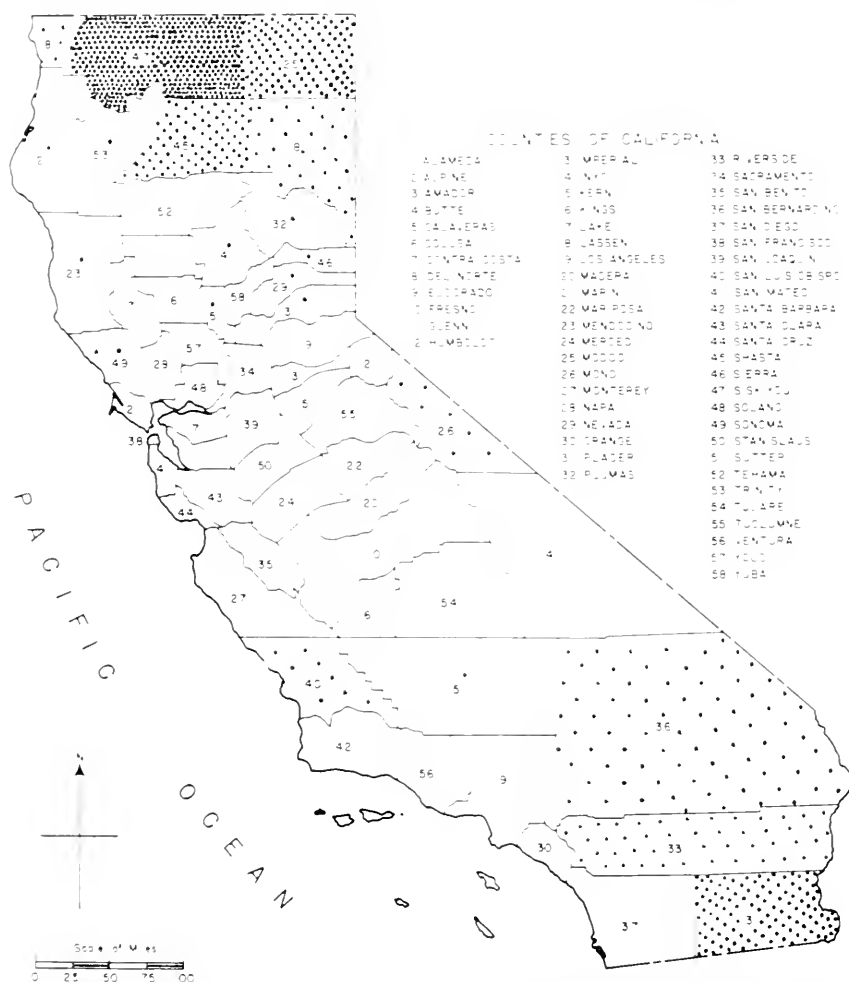


FIG. 23. Muskrat catch for the 1940-41 season. Each dot represents 1 10 of 1 per cent of the total catch for the State. Dots are placed evenly throughout the county and do not necessarily show just where the muskrats were caught.

that encouraged trappers to commence transplanting muskrats to new areas. The catch again started to increase in 1933 coincident with the increase and spread of planted muskrats in northeastern California. At the same time prices started on a long-term upward trend, but this was probably largely due to the increased proportion of the more valuable northern muskrat in the catch.

In 1940 the catch was just double that of 1939, a spectacular increase. At this same time war conditions cut off a large part of the shipments of China mink and kolinsky from the Orient. Furriers developed new processes for blending, dyeing, and cutting muskrat pelts whereby muskrat fur was made to resemble mink. "Mink-dyed muskrat" became fashionable, replacing many of the furs that could not be

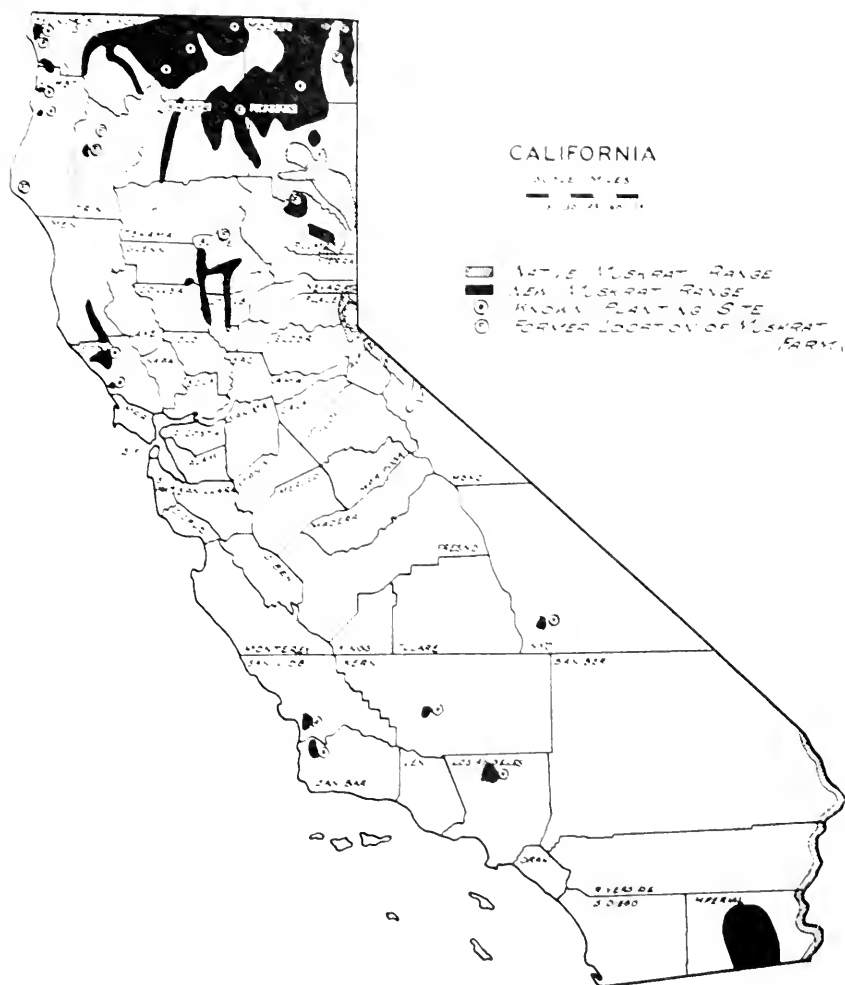


FIG. 24. The distribution of muskrats in California.

obtained from overseas. In 1942 furriers estimated that 95 per cent of all muskrat fur was dyed or blended. As a result the trappers received more for their furs and this stimulated heavy trapping. Fortunately at this time muskrats in California were more abundant than ever before, so trappers made good catches.

The map (Fig. 23) shows strikingly that the bulk of the muskrat trapping is done at either end of the State and also that Siskiyou

County is by far the most important muskrat-producing county. It should be understood that the catch represented by dots in Fig. 23 should be restricted within the boundaries outlined in Fig. 24.

Most of the original stock of transplanted muskrats was brought into California from other States.³ Trappers and fur farmers answered advertisements in sporting magazines offering live muskrats for sale. Occasionally it even happened that two persons in the same district made plants of muskrats at about the same time. In other instances trappers imported muskrats with fur of high quality in an attempt to improve that of the resident animals. The result has been a great hodge-podge of types. One fur buyer claims that he can recognize differences in the fur of muskrats from 20 different localities in north-eastern California. The investigators have attempted to unravel the complicated history of all of these plants, but in many instances their findings have been scant. Most of the historical information was obtained through interviews with informed people, but in certain situations corroborating evidence was obtained through examination and comparison of skins and skulls of the animals.

We are especially indebted to Dr. Tracy I. Storer of the University of California, who gave us access to his extensive notes on muskrats. His review of the history of muskrat introductions published in 1938⁴ included much of the historical information included in this paper. Our thanks are also due to Mr. W. C. Jacobsen of the California State Department of Agriculture, who gave us lists of muskrat localities. All of this material has been consolidated in the notes which follow: (For the convenience of the reader, the counties have been arranged in geographical rather than in alphabetical sequence.)

MODOC COUNTY

Surprise Valley. Twelve pairs of muskrats were introduced into Surprise Valley in 1926 by Joshua Hutchinson and Joshua Streif, both of Lake City, in a fenced marsh one-half mile south of Lake City. These were purchased in Battle Mountain, Nevada. Two years later F. W. McKenzie of Fort Bidwell brought in two or three pairs of muskrats from Nevada and placed them in an enclosure, but later liberated them in Bidwell Creek. These muskrats, then, are of the subspecies *mergens*.

In 1940 a survey showed that muskrats were found in small numbers in the following localities: Dismal Swamp (Bidwell Creek), Cowhead Lake, Meadows north of Cedarville, Fort Bidwell, Eagleville.

Goose Lake. In 1930 a Mr. Bassett of Fairport started a fur farming venture by bringing in muskrats (source unknown) and releasing them in a pen near Fairport. The farm was not successful and the muskrats were soon liberated in Goose Lake near Fairport.

In 1932 A. J. Onsley and Charles Combs of Lakeview, Oregon, started a muskrat farm at Dog Lake, Oregon. The muskrats were

³In 1929 a regulation of the California State Fish and Game Commission (incorporated into the Fish and Game Code in 1933) made it unlawful to transport or possess live muskrats in the region west of the crest of the Cascade-Sierra Nevada mountain system or in any watershed draining into the Pacific Ocean, except the drainage basin of the Klamath River. It also made it unlawful to import live muskrats into any part of California from outside the state.

⁴Storer, Tracy I. The muskrat as a native and an alien: a chapter in the history of animal acclimatization. California Fish and Game, vol. 24, no. 2, pp. 159-175, 1938.

released in Dog Lake and these moved down Drews Creek into Goose Lake.

Muskrats were found in the Goose Lake area at the following localities in 1940: New Pine Creek, Willow Creek, Lassen Creek, Davis Creek.

In 1941-42 two trappers caught 270 muskrats from Goose Lake near Fairport.

Devils Garden. Muskrats are found in Lost River, Willow Creek, and Rattlesnake Creek. Lost River provides a migration route from Tule Lake to Willow Creek. Specimens taken from this watershed show characteristics of the Tule Lake muskrat.

Muskrats found in Rattlesnake Creek, Big Sage Reservoir, Ingals Swamp, and Thomas and Raker reservoirs, though not examined by us, are probably of the Pit River stock. Avanzino Swamp could have been populated by muskrats from either watershed.

Alturas Vicinity. After the escape of muskrats from the fur farm at Fall River in 1932 (see p. ---), there was a gradual spread up and down the Pit River. All of the suitable habitats extending to the headwaters probably would have been populated ultimately by these muskrats through natural migration, but interested people anxious for more immediate revenue hurried the process by transplantations.

In 1936 five pairs of muskrats from Tule Lake, Siskiyou County, were planted on the Merlini Ranch, 12 miles southwest of Alturas. These were large, dark animals easily distinguished from the smaller, red form of the lower part of the Pit River. Two specimens taken in 1940 from the headwaters of the Pit, 20 miles north of Alturas, are large in size and dark in color. Skull measurements compare most favorably with specimens from Tule Lake, but the skins show slightly more red on the sides, indicating that there has been some admixture with the smaller, red muskrat (*cinnaamonia*) of the lower Pit River.

In 1940 muskrats were found along the Pit River and adjacent marshes in this vicinity and in the following tributaries: Roberts Creek, Joseph Creek, Tom Creek, Shields Creek, Hot Creek, Essex Reservoir, Clover Swale, Jack Swamp, Dobe Swale, Fairchild Swamp, Stonecoal Valley, Upper and Lower Roberts Reservoir, Gooch Swamp, Egg Lake, Pine Creek, East Side Canal, West Side Canal, Fitzhugh Creek, Jess Valley.

LASSEN COUNTY

Big Valley. Muskrats are found throughout this valley, in the Pit River, in swamps, and in tributaries and ditches. In 1936 three pairs of muskrats taken from Tule Lake were planted in Big Valley in an effort to "improve the strain."

Ash Creek. Muskrats are found in small numbers along this creek, with the exception of the Ash Valley portion which supports a large population.

Little Valley. Muskrats probably migrated into Little and Dixie valleys from the Pit River.

Madeline Plains. The first muskrats were reported here in 1938. They probably invaded Madeline Plains by moving up the south fork of the

Pit River and across Tule Reservoir. It is possible, however, that these muskrats crossed the ridge of South Fork Mountain from Ash Valley during the winter period when heavy rains provide temporary water-courses.

Honey Lake. Native muskrats (*mergens*) are found in Honey Lake Valley and its tributary streams. In 1940 muskrat sign was found in Long Valley, Susan River, and Willow Creek.

Eagle Lake. A few native muskrats are found in Pine Creek near its entrance into Eagle Lake.

SHASTA COUNTY

Fall River Valley. In 1930, after approval of the County and State Department of Agriculture, the Division of Fish and Game issued a permit for the operation of a muskrat farm at Mud Lake on Fall River north of McArthur. In 1930, 40 pairs of muskrats (source unknown) were brought in and kept in metal cages. In 1931, a marsh was fenced with 18 gauge, 1 inch wire netting, 5 feet high and buried 12 inches below ground level. A 14 inch sheet-iron strip along the top of the netting prevented muskrats from climbing over the fence. The muskrats were released in the enclosure in September, 1931. In 1932, 500 more muskrats (*cinnamomina*) were brought in from South Dakota and released in the enclosure.

In March 1933 the first report was received by the State Department of Agriculture that muskrats were loose in Fall River Valley. Seven trappers were hired by the California State Department of Agriculture and the Pacific Gas and Electric Company, to clean the muskrats out of the valley. In May and June 1933, these men trapped a total of 2,966 muskrats, indicating that muskrats must have escaped earlier and bred in the marsh for more than one season in order to build up such a population.

In 1942, 27 trappers reported taking 7,396 muskrats from Fall River Valley and its tributary streams. Their total income was \$8,861 or an average income of \$328.18 for each trapper.

Lower Pit River. Trappers' reports show that muskrats are scarce in the Pit River between Fall River Mills and the junction with the Sacramento River. In 1942 two trappers reported taking 190 muskrats from Hat Creek; another took 15 muskrats from Montgomery Creek, and a fourth took 150 muskrats from the Pit River at Lake Britton.

Anderson Valley. In March 1935 a Redding newspaper reported that Ted Jessen had killed a muskrat on his land. This was thought to be the first record of muskrats in the Sacramento River near Redding. It was assumed at the time that muskrats had moved down the Pit River to this region. An inspection of several hundred pelts taken in the vicinity of Anderson in 1942 showed that the fur is dark and lacking in the pale red color of the typical Pit River muskrat. In all probability these muskrats were planted here and the original stock was not from the Pit River.

Each summer G. F. Fowler of Redding, who does muskrat control work for the Shasta County Agricultural Commission, traps about

100 muskrats from the high line canal bordering Anderson Valley. B. F. Stroup, Shasta County Agricultural Commissioner, stated in 1940 that only one break in a canal in the Anderson Irrigation District could definitely be attributed to muskrats.

In 1942 two trappers took 137 muskrats along the Sacramento River near Anderson. Another trapper reported taking three muskrats on the river just north of Redding. Farther up the Sacramento a trapper took nine muskrats at Elmore. As stated above, muskrats have been reported as far up as Dunsmuir, but the habitat is poor here and no sign of them could be found by the writers in 1940. We have also been unable to locate muskrat sign on the Sacramento River near Red Bluff, Los Molinos and Vina.



FIG. 25. Muskrat house in Tule Lake, Siskiyou County, California.

SISKIYOU COUNTY

Tule Lake. In 1930 Tule Lake was stocked with 22 pairs of muskrats purchased from Michigan. Trapping on the Tule Lake National Wildlife Refuge was started in the season of 1934-35 and the catch thereafter was as follows:

<i>Year</i>	<i>Number of Muskrats</i>	<i>Number of Trappers</i>
1934-35-----	1,508-----	5
1935-36-----	957-----	1
1936-37-----	2,768-----	5
1937-38-----	16,623-----	9
1938-39-----	19,694-----	14 (2 with very small catches)
1939-40-----	31,252-----	12 (3 with very small catches)
1940-41-----	26,834-----	14 (each trapper limited to 2,000)

The trapping on this refuge has been under supervision of the U. S. Fish and Wildlife Service. The trappers are selected by the refuge management and areas are allotted to each trapper. The pelt of the Tule Lake muskrat is recognized by fur buyers as ranking among the best in the nation. In 1941 the trappers on the refuge received an average of \$1.60 for their pelts as contrasted to an average of \$1 for those from the remainder of northern California.

Lower Klamath Lake. Muskrats in this area are found in Sheepy Lake, Sheep Camp Lake, Deep Lake, Cottonwood Creek and Willow Creek. They probably migrated here from Upper Klamath Lake.

Orr Lake. In 1937 Pete Vistonti trapped six muskrats from Sheepy Lake, Siskiyou County, and released them in Orr Lake. In 1942 two trappers took 154 muskrats in the vicinity of Orr Lake.

Shasta River and Little Shasta River. In 1927 Ed Terwilliger obtained 15 muskrats from Upper Klamath Lake and planted them on his ranch at Hole-in-the-Ground Swamp. In 1942, 16 trappers reported taking 4,333 muskrats from these two rivers and their tributaries. They sold for \$5,858.54, bringing an average return of \$366.16 to each trapper. Trappers take a surprisingly large proportion of their muskrats in drain ditches and small lakes which only contain water in the rainy season.

Scott Valley. In 1942, 23 trappers reported taking 1,697 muskrats from Scott Valley and its tributaries. Some of the more frequently mentioned localities were: Oro Fino Creek, Quartz Valley, Big Slough, Forks of Salmon. These records indicate that muskrats are numerous between Forks of Salmon and Shackleford Creek.

Happy Camp. One trapper reported taking two muskrats at Happy Camp in 1942.

Clear Creek. Two trappers reported taking a muskrat apiece at Clear Creek in 1942.

DEL NORTE COUNTY

Smith River. H. J. High is reported to have established a muskrat farm at Smith River in 1931 (T. I. Storer, MS). Mr. High was unknown to several residents of the town of Smith River who were questioned by us. Walter Lockwood of Smith River reported to us that in 1931 he bought 24 muskrats from a farm in Florida in answer to an advertisement in a magazine. These were planted in Lake Earl and a few were put in a small marsh on the Lawrence Cadry Ranch near Lake Earl. Muskrat sign was found in this isolated marsh in 1940.

A marsh situated $1\frac{1}{2}$ miles south of Crescent City, adjoining Highway 101, harbors a few muskrats. Local boys trap about 40 there each year.

Klamath River. Muskrats are found in small numbers in the Klamath River but the habitat is poor. Whether the original stock migrated down the river from Upper Klamath Lake or Shasta River, or whether they were planted there is not known.

HUMBOLDT COUNTY

Prairie Creek. A trapper in Orick reports to us that he trapped nine muskrats from the Klamath River and moved them into Prairie Creek in 1937. In 1941 he caught two in Prairie Creek and heard of another trapper who caught two more in Redwood Creek. Muskrat sign was found in these streams in 1941.

Little River. A very small amount of muskrat sign was found in Little River near the crossing of Highway 101 in 1940.

Petrolia. Charles Wright of Petrolia in 1931 bought five pairs of muskrats from a farm in Denver, Colorado, and released them in a fenced enclosure between the town of Petrolia and the Mattole River. Some died and three or four escaped. They all soon disappeared.

TRINITY COUNTY

Burnt Ranch. In 1927 Shelby W. Coskrey imported five pairs of muskrats from Paisley, Oregon, and planted them in a marsh of about 13 acres near Burnt Ranch. In 1928 he trapped 150 muskrats but the following year the dam broke and the marsh was nearly drained. Only a few muskrats were left in 1940, and it was reported that some had moved to the adjacent section of the Trinity River.

Elder Creek. According to Fish and Game Warden C. L. Gourley, a muskrat and mink farm was started by Roy Gourley at Elder Creek near Hyampom in 1928. The muskrats were soon released in Elder Creek.

MENDOCINO COUNTY

Russian River. Muskrats were first noticed by trappers in the Russian River district in 1940. A dead muskrat was picked up on the highway near Talmadge in 1940. A trapper reported taking two muskrats near Ukiah in 1942. Another trapper took three muskrats near Hopland in 1942. The river provides little good muskrat habitat, so it is probable that muskrats will never become numerous there.

SONOMA COUNTY

Russian River. Percy Williams of Healdsburg secured about 12 muskrats from Montana in 1928 and started a muskrat farm on his place near Alexander Valley. These were released the same year in the Russian River. In 1940 muskrats were found along the entire length of the river in this county. They were concentrated in sloughs and marshes that connect with the river. Those in the river lived mostly in high banks evidently for protection from flood waters.

Lagunas Creek, a tributary of the Russian River that flows through Sebastopol, offers the best habitat for muskrats in this watershed. Trappers in 1942 reported taking 125 muskrats in this district and undoubtedly many more were taken by minors.

Salmon Creek. A marsh near the mouth of Salmon Creek, inspected in 1940, showed a little muskrat sign. Obviously muskrats had been planted in this isolated locality.

BUTTE COUNTY

Feather River. H. S. Anderson of Oroville caught three muskrats from the Feather River near the junction of the Sutter-Butte Canal in 1929. This is the earliest record of muskrats in the Sacramento Valley that we have been able to locate. A small population seems to have persisted in this district. In 1939-40 a trapper caught 15 muskrats here. Trappers who worked both the river banks and adjacent dredger holes took 13 muskrats in 1939-40, 59 in 1940-41, and 57 in 1941-42.

Butte Creek, White Mallard Canal. The first muskrats from this locality were trapped on the Wild Goose Country Club on Butte Creek in the season of 1937-38. In 1939-40 a trapper took 13 muskrats in this vicinity, and in 1940-41 the same trapper took 16 muskrats. White Mallard Canal was checked for one mile southwest of Butte Creek on September 1, 1940, and much muskrat sign was found. Two muskrats were killed on Grey Lodge Refuge in 1942. In December 1942 nine caved-in burrows were counted along one mile of roadbed on the refuge. The indications are that muskrats are well established in an area at least four miles in diameter in this vicinity.

Two specimens taken from this locality were unmistakably darker than the muskrat of the lower Pit River and skull characteristics seemed to differ. We have not had the opportunity to compare specimens with those found in the vicinity of Anderson, but off-hand the two appear to be similar.

Dodgeland, 18 miles south of Chico. Muskrats were seen here in 1938 by H. J. Pickard of Chico. He caught 90 muskrats during the 1942 season in the sloughs adjoining the Sacramento River. It is estimated that there are at least 25 miles of tule-bordered sloughs in this district, all of which afford excellent muskrat habitat.

M and T Ranch, 7 miles southwest of Chico. Ditch tenders report seeing muskrats in the canals near the junction of Chico Creek and the Sacramento River. One of them shot six muskrats here in the spring of 1942. Two specimens were collected from Edgar Slough in October, 1942.

Coutolenc. A muskrat farm was started here in 1925 with muskrats purchased from Denver, Colorado. The muskrats did not seem to breed and soon disappeared. It was reported that they were killed by house cats.

SUTTER COUNTY

Sutter Basin By-Pass. In 1938 employees of the California State Division of Water Resources reported seeing muskrats near the Spurgeon Gun Club and also near the junction of the Wadsworth Canal and the Sutter By-pass. In 1940, muskrat sign was found near the junction of Tisdale Weir and Sutter By-pass.

Storer (1938) states "In January, 1938, a report was received of a muskrat having been shot near Live Oak, adjacent to the Feather River." Residents of Marysville reported shooting muskrats in Nigger Jack Slough near Marysville in 1941. Muskrat sign was found in Plumas Lake, 8 miles south of Marysville, in 1942.

GLENN COUNTY

On September 20, 1940, muskrat sign was found on Willow and Logan creeks, 4 miles east of Norman, on property adjoining the Sacramento Migratory Waterfowl Refuge.

PLUMAS COUNTY

Indian Valley. In 1925, W. H. Stanfords established a muskrat and beaver farm in Indian Valley. His muskrats were native animals (*mergens*) procured from Honey Lake Valley. A few years after the establishment of the farm the cages were destroyed by flood waters from Indian Creek and the animals escaped. In 1940 muskrat sign was found in Indian Valley, Wolf Creek and Red Clover Creek. In 1942 two trappers reported taking 40 muskrats from Indian Valley.

Sierra Valley. Muskrats were seen by residents of Sierra Valley as early as 1930. Their origin is unknown. In 1940 muskrat sign was found in the Feather River as far down as Sloat. More sign was found in Little Last Chance Creek and in marshy places throughout Sierra Valley.

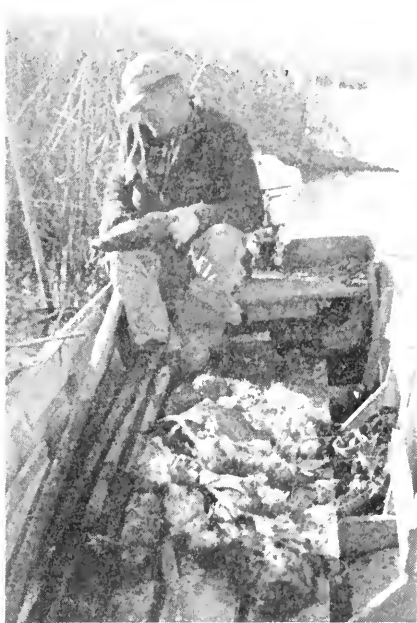


FIG. 26. A trapper with his days catch, Tule Lake, Siskiyou County, California.

SIERRA COUNTY

Native muskrats (*mergens*) are found in the Little Truckee River as far up as Weber and Independence lakes. In the Feather River drainage they are found in Gold Lake.

NEVADA COUNTY

Native muskrats occur in the Truckee River in small numbers.

PLACER COUNTY

Muskrats are trapped each year in a slow-moving stretch of the Truckee River near the outlet of Lake Tahoe. A trapper reported taking 27 muskrats in 1942.

EL DORADO COUNTY

Native muskrats occur in small numbers in Al Tahoe Marsh at the south end of Lake Tahoe. There are a few in a lagoon between Emerald Bay and Camp Richardson. C. E. Berry of the California

Stage 20, about 10 miles from the lake, a muskrat in Fallen Leaf Lake

ALPINE COUNTY

Musk-rats are native to the east and west forks of the Carson River. In 1941 in Shoshone was a small colony on the east fork of the Carson River. A small lake near Badley Valley at an altitude of 6,500 feet.

MONO COUNTY

Musk-rats are native to the east and west forks of the Walker River. In the Badley Valley near Colville, trappers reported taking 847 muskrats in 1942. There is little muskrat habitat in Badley or Valley, but muskrat sign was found in Upper Twin Lake in 1942.

INYO COUNTY

Little Lake. "William Bramlette caught individuals of the race *M. m. m. m.* in 1925 to refine cattails in the lake, which they have done since. We have migrated along a connecting stream that sinks in the adjacent desert. No damage has occurred and the animals are far from their water or they are in the area." (Storer, 1945). In 1941 muskrats were found in the lake and cattails nearly exterminated in this locality.

KERN COUNTY

Kern River and Buena Vista Lake. Musk-rats, presumably of subspecies *mexicanus*, were introduced in 1911 or earlier. The actual date, source, and means are unknown (Storer, 1945). In 1941 muskrats were found in small numbers in the lower end of the irrigation canal, which are located about six miles south of Bakersfield.

SAN LUIS OBISPO COUNTY

Oso Flaco Lake. Twenty-five muskrats, taken from Guadalupe Lake, were planted here in 1939. Conditions are excellent and the muskrats thriving as evidenced by the catch of 845 muskrats by one trapper in this small lake in 1941-42.

Dune Lakes. The eight Dune Lakes total 265 acres. The shores of all are lined with dense growths of round-stemmed reeds, cattails, and sedges, providing abundant food. In 1939-40 a trapper took 840 muskrats and in 1940-41 caught 513 muskrats. These lakes were stocked with muskrats from Oso Flaco Lake.

Oceano. Musk-rats have migrated into this vicinity from Dune Lakes. The vicinity is accessible and open to anyone who wishes to trap. Many miners, from whom no reports of catch are received, trap the area. The three licensed trappers who took muskrats here in 1941-42 caught 827.

SANTA BARBARA COUNTY

Guadalupe Lake. Conditions in the vicinity of Guadalupe Lake in 1940 were found to be substantially the same as those reported by Storer (1935). These muskrats were originally obtained from the Colorado River and planted by W. N. Morrison of Santa Maria in 1927.

Guadalupe Lake is now dry, but a few muskrats persist in the ditches between the lake bed and the ocean. The farmers are favorable toward the muskrats here as they aid in keeping tules from the ditches. An owner of a duck club complains that muskrats cut his ditch banks after he floods his field for the shooting season.

LOS ANGELES COUNTY

Mundona Lakes (10 miles west of Lancaster). In 1936, Eli Munz arranged to secure 20 muskrats from a trapper at Blythe in the hope that they would clean out the cat-tails in a pair of small lakes, called Mundona Lakes, on his property. The trapper attempted to deliver the 20 muskrats in his automobile, but several died en route and he ultimately arrived with only six. Munz claims that he saw two lying dead on the shores of the lake shortly after the plant was made. The remaining muskrats evidently thrived, for when the lakes were inspected in 1940, muskrat holes, runways, and tracks were found on the upper lake. Only a few small patches of cat-tails remained. The result has been beneficial for the area is used as a picnic ground and swimming pool and tules are undesirable here. Muskrats have been reported in the adjacent Lake Hughes, but at the time of inspection in 1940, the water level was low and no muskrat sign could be found.

Antelope Valley. Muskrat sign was found on Antelope Valley and Piute Country clubs, 5 miles north of Lancaster. Local residents say that muskrats now occur in every inhabitable marsh throughout Antelope Valley. They seem to have been present for many years, but their origin is unknown.

RIVERSIDE AND SAN BERNARDINO COUNTIES

In the parts of the Colorado River included within these two counties 34 trappers in 1942 took 8,214 muskrats which brought them a total income of \$4,178.53, or an average return of \$122.89 for each trapper. The area open to trapping was restricted in 1941 by the closing of the Imperial National Wildlife Refuge which corresponds with the land acquired by the Imperial and Parker Reservoir projects.

IMPERIAL COUNTY

Imperial Valley. The building of the International Canal from the Colorado River to the Imperial Valley in 1901, and the consequent flooding of the valley, provided much new muskrat habitat. Muskrats moved into this area and occupied the canals and drain ditches. For many years the irrigation districts offered bounties for the animals, and later trappers were hired by the districts to control muskrat numbers. In 1941, the Imperial Irrigation District was resorting to burning of vegetation on ditch banks followed by spraying of the earthen banks with oil. In three years, 8,000 miles of ditches had been so treated at a cost of \$9.96 a mile. Probably this process is as effective in eliminating seepage as it is in controlling damage by muskrats and pocket gophers, but it has resulted in the near elimination of muskrat habitats in these treated irrigation ditches. Muskrats now are most numerous in Alamo and New rivers, where most trappers now make their catches.

In 1942, 16 trappers in Imperial Valley reported taking 7,503 muskrats which brought them \$3,479.36, or an average income of \$217.46 for each trapper.

Colorado River. Native sandrats are numerous along the shores of the Colorado. In 1942, 11 trappers reported taking 3,142 muskrats on the Colorado River in Imperial County which brought them \$1,261.46 or \$114.68 for each trapper.

SUMMARY

Native muskrats originally occurred in California in a very limited range east of the Sierra Nevada on the Honey Lake, Truckee, Carson and Walker watersheds. Also, a small, pale muskrat called "sandrat" is native to the Colorado River. It invaded the Imperial Valley in large numbers with the expansion of the irrigation system there.

Trappers interested in increasing the range of this valuable furbearer, introduced them into new areas and soon muskrats had spread into nearly every inhabitable part of northeastern California. In addition, spotty occurrences were showing up in other parts of the state. In 1942 muskrats were rapidly increasing in the Sacramento Valley where tremendous marsh areas are open to their further spread.

Because of this great increase in the numbers of planted muskrats, the catch increased phenominally. In the winter of 1931-32 the 1,300 trappers who reported their catches took only 150 muskrats. The catch increased each year until the season of 1939-40, when 1,179 trappers reported taking 69,596 muskrats.

The writers believe that the annotated list of localities included in this paper is very nearly complete. It was compiled through personal contact with trappers, ranchers, fur buyers, wardens and other cooperators. Nearly every locality has been inspected by the investigators.

During the survey certain problems that critically affect muskrats were disclosed and intensive work is continuing on these.

THE FISH-EATING BATS OF THE GULF OF CALIFORNIA¹

By E. W. GUDGER

*American Museum of Natural History
New York City*

To most of my readers the allegation conveyed in the title of this article seems entirely preposterous. They know their bats to be insect feeders and they have heard or read that the vampire bats of South America suck the blood of horses, cattle, and even of man. But that bats eat fish—"Absurd!"

However, it is a known fact that in India and Burma certain bats eat fish—though no one has seen them catch them. Also in some of the islands of the Caribbean Sea and in various parts of northern South America bordering on this sea, bats have been found to be fish-eaters and furthermore have been seen in the act of catching fish. But that there are fish-eating bats in the central part of the Gulf of California, within a few hundred miles of the United States border, will come as a surprise to most people.

This Gulf of California bat bears the euphonious name of *Pizonyx*, meaning grasping claw, and how correctly it is named, we shall presently see. It has no common name. All the other fishing bats are dwellers in the tropics; but outside this zone, yet still in a warm temperate region, fishing bats are found in the Gulf of California.

The determination of the feeding habits of *Pizonyx* by a brilliant conjecture from the structure of dried or mummied specimens, amply confirmed years later by dissection of fresh *Pizonyxes*, is a fine example of high-grade scientific deduction.

An interesting contrast exists between this bat and that one which fishes in the Caribbean region and whose habits have been studied by various investigators. *Noctilio*, the night-flyer, has a very extensive distribution, being found throughout tropical South America and as far north as Cuba and southern Mexico. On the other hand, *Pizonyx* is at this time known from but four localities in the Gulf of California. Three of these are on the northern half of the east coast of Lower California: Cardonal Island, a tiny speck of land in the Sal si Puedes group; Isla Partida (only 12 miles north of Cardonal); and, still farther north, Isla Encantada. The fourth is Guaymas, on the mainland, where a dessicated specimen was once picked up on the beach. However, it is probable that when the islands and mainlands of the Gulf have been intensively explored for their bat population, *Pizonyx* will be found more widely distributed—possibly throughout the whole region.

The local habitat of *Noctilio*, the fishing bat of the Caribbean region, is that of any tropical bat and calls for no special comment.

¹ Submitted for publication, June, 1942.

Not so that of *Pizonyx*. Its habitat is possibly the most anomalous known for any bat. All specimens that have ever been collected (save the mummy) were found under loose stones on the islands named and in association with a species of petrel. Indeed the first collector (Dignet in 1900) thought that the bats fed on the excreta of this bird.

Miller and Allen (to whom we owe the brilliant conjecture as to its habits), like most other students of this bat, had only eviscerated and dried museum specimens, and hence were unable to make any determination of their food. Others with fresher material had found the stomachs empty or containing only a few mites, feathers and some bat-hairs. So there was nothing to go on. But our authors state that its physical peculiarities (especially those to be noted presently) make *Pizonyx* of all North American bats the one most easily recognized. These things led them to say:

These peculiarities and more particularly the seemingly anomalous habitat and geographical range make it appear to be possible that this bat has some unusual mode of life. * * * While we are left in complete ignorance as to the animal's food habits, it seems not improbable that the enlarged foot and claws, the relative freedom of the leg from the wing membrane, and the elongation of the cusps of the teeth may all be associated with a diet consisting at least partly of fish.



FIG. 27. Foot of *Pizonyx* (x2), showing the elongated toes and the hooked claws. Drawn from a specimen in the American Museum of Natural History.

Miller and Allen refer to the size and length of the feet and claws and to the sharp-cusped teeth of *Pizonyx*, but give no figure of either. From an alcoholic specimen in the American Museum I have had drawn a figure of the foot (Fig. 27). This shows how well justified is our authors' description—" . . . the enlarged foot and claws." Note the long bones of the foot and the long slender hooked claws, measuring about 7 mm. straight across the arc and about half as much more around the curve. These are gaff hooks admirably adapted for snatching little fishes from the surface of the water.

But we still wish to know about the teeth. Long before the appearance of the joint article referred to, Miller had published (1907) a figure of the skull of *Pizonyx* in lateral view. This is reproduced herein (Fig. 28) so that it may be seen that the jaws are filled with long, slender sharp-cusped teeth. In clawed feet and pointed teeth, *Pizonyx* closely resembles the Caribbean bat, *Noctilio*. Since *Noctilio* is known to be a fish-eater, Miller and Allen ventured the conjecture

that *Pizonyx* has like food habits. And now we shall see how this brilliant conjecture was a few years later to become an established fact.

Burt in January, 1932, visited Isla Partida in the Gulf and found *Pizonyx* bats abundant under rocks. Since the bats are nocturnal feeders and since their food and feeding habits were the particular matters to be investigated, specimens were collected in the morning. The bats came out to feed too late in the evening and returned too early in the morning for any observation to be made on their fishing habits. But the stomachs of those collected were dissected and "were found to be distended with finely chewed fish remains." Thus were confirmed the conclusions of Miller and Allen. The fish scales were ascertained to be those of a sardine found in vast schools in these waters. Much bat guano was found in the crevices in the rocks where the bats lived. "Upon examination, the guano proved to be made up entirely of fish remains, chiefly scales with an occasional small fish bone."

Burt confessed that their method of catching the sardines was a mystery to him but he thought that "the specialized claws aid the animals in procuring their food." Nor is it known to this day how the fish are taken, and since these bats are thought to go out to fish late in the evening and to return early in the morning, the mystery is not likely to be solved soon. However, *Noctilio*, the Caribbean fishing bat, has been seen at Monos Island, at the southwest corner of Trinidad, fishing just before twilight. Many California exploring and fishing expeditions have gone and others will go to catch fishes and to study the wonderful fish fauna of the Gulf. If the news of the fishing habits of *Pizonyx* becomes widely known, perhaps someone will go to some of the islands named, anchor there, watch for and see this interesting bat catching its supper of sardines.

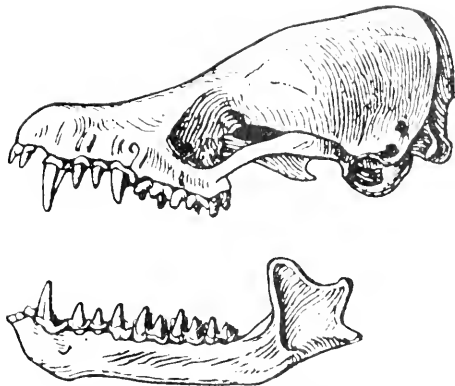


FIG. 28. Skull and jaws of *Pizonyx* (x3). Note large canines and molars with pointed cusps adapted for piercing fish scales. After Miller, 1907.

Literature Cited

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1932. The fish-eating habits of [the bat] *Pizonyx vicesi*. Journ. Mammalogy, 13, 363-365.

Miller, Gerrit S. and Allen, Gloyer M.

1928. The American bats of the genera *Myotis* and *Pizonyx*. Bull. U. S. Nat. Mus., no. 144 (*Pizonyx* a probable fish-eater, pp. 209-213.)

EDITORIALS AND NOTES

GRUNION IN MONTEREY BAY

Grunion, *Leuresthes tenuis*, occur along sandy shores from Balleas Bay, Lower California, to San Francisco, California. However, north of Pt. Conception they are uncommon enough to arouse local interest, whenever specimens are taken. At Monterey, occasional reports of the presence of grunion have, in most cases, been found to be the surf smelt, *Hypomus pretiosus*. On October 19, 1942, Ed and Howard Low of the American Fish Company, found two grunion in a haul of sardines from off Monterey. These specimens, $6\frac{3}{4}$ and $7\frac{1}{4}$ inches, total length, were turned over to the author for identification. Professor Rolf L. Bolin of the Hopkins Marine Station, remembers having had two grunion that had been caught off Monterey turned over to him for identification about three years ago. No doubt occasional specimens have been taken of which there is no official record.

The grunion belongs to the silverside family, *Atherinidae*, in which are also classed the jack smelt and the bay smelt or panzarotti. This family lacks the adipose fin that is possessed by members of the family of true smelts, *Osmocridae*. The grunion may be distinguished from the other two members of the silverside family found in California, the jack smelt and the bay smelt, by the following characters: Front of the first dorsal fin over front of anal fin; lower jaw shorter than upper jaw; front of the upper jaw (premaxillary) capable of being drawn out for a considerable distance to form a tube; absence of teeth in the mouth; color, grayish green above, silvery below, with a lateral silvery streak that is tinged with blue, extending the length of the body. This fish rarely exceeds seven inches in total length.

The spawning habit of this fish is both unique and curious. It spawns on certain sandy beaches, beginning the last of March, the second night after full moon, at high tide, and for several nights thereafter and at two week intervals, until August. Maximum spawning periods are attained in April and May. The female buries itself in sand, tail down, up to the pectoral fin, the eggs are spawned in this "pocket," and the sperm of the male sinks down to fertilize them there. The eggs remain in these pockets for two weeks or longer, until washed out by the next series of tides. (See Clark, F. N., "California Fish and Game," vol. 24, no. 1, pp. 49-54, Jan., 1938.)

Grunion have not been discovered spawning on any of the beaches along Monterey Bay. The spawning activities of the surf smelt, in the surf, have been attributed mistakenly to the grunion. An examination of the scales of the two grunion reported above showed two spawning scars for the $6\frac{3}{4}$ inch specimen and three scars for the $7\frac{1}{4}$ inch specimen. Inasmuch as spawning grunion have not been noted in this region, it is highly probable that the grunion that have appeared in this region are stragglers from southern California.—J. B. Phillips, Bureau of Marine Fisheries, California Division of Fish and Game, November, 1942.

ANOTHER WALL-EYED POLLACK AT MONTEREY

A wall-eyed pollack, *Theragra chalcogramma fucensis*, was caught in 115 fathoms of water off Carmel, California, on November 27, 1942, by a Monterey market fisherman who was fishing for rockfish. This pollack was 20½ inches in total length, one-half inch longer than the specimen reported from Monterey Bay on May 7, 1942 (Phillips, J. B., CALIFORNIA FISH AND GAME, vol. 28, no. 3, pp. 155-156, 1942).

The pollack is a member of the family *Gadidae* (the true cods) and occurs along the Pacific coast of North America south to Monterey Bay. There are very few records, however, of the pollack in California waters.—J. B. Phillips, *Bureau of Marine Fisheries, California Division of Fish and Game, November, 1942.*

REHABILITATION OF A MODOC COUNTY RESERVOIR FOR TROUT FISHING

Ballard Reservoir, sometimes known as Toreson Reservoir, in the Pit River drainage in Modoc County, has been rehabilitated for trout fishing, at the suggestion and with the cooperation of Fish and Game Commissioner W. B. Williams.

Until 1932 this reservoir had furnished excellent rainbow fishing, but when it was drained for repairs in 1933 most of these fish were lost. It was restocked with Loch Leven trout. Subsequently chubs gained access to the lake, very possibly introduced by some careless fisherman as bait, and in recent years have become so abundant that trout fishing has practically ceased. September 28 to 30, 1942, a crew of three men from the Bureau of Fish Conservation poisoned the reservoir with powdered cube root, and succeeded in killing all the fish in it and in the lower one and one-half miles of its tributary, Toms Creek.

The reservoir was estimated to have a surface area of 25 acres and an average depth of six feet at the time of poisoning. However, the average depth when full is considerably greater and the surface area is about 50 acres. Toms Creek, although very small in late summer, does permit natural propagation which can be expected to aid in the maintaining of the fishery.

Following is an estimate of the fish killed in the poisoning operations:

Chubs (<i>Siphateles bicolor</i>)	350,000
Catfish (<i>Ameiurus nebulosus</i>)	50,000
Rainbow trout fingerlings	1,000
Rainbow trout adults	25
Loch Leven trout	40
Bullheads (<i>Cottus Sp.</i>)	100

The lake was restocked with five-inch rainbow in early December, 1942. In so far as is known its chemical nature has not changed since the time prior to 1933 when it furnished such good rainbow fishing. Therefore, it is logical to suppose that with the chubs, catfish and large predatory Loch Leven removed, this species should again thrive and produce the same excellent fishing.—J. H. Wales, *Bureau of Fish Conservation, California Division of Fish and Game, December, 1942.*

TWENTY-FIVE YEARS AGO IN CALIFORNIA FISH AND GAME

The April, 1918, issue of CALIFORNIA FISH AND GAME was designated "The Herring Number." Leading articles were "The Herrings and Herring-like Fishes" by Dr. E. C. Starks of Stanford University, and "The Herring and the Development of the Herring Industry in California" by N. B. Scofield. The purpose of the issue, present day readers will be interested to learn, was to "encourage the use of herring as a meat substitute during the war emergency."

It appears that earnest efforts were made at that time to bring about increased herring consumption. Total landings rose from 2,000,000 pounds in 1916 to over 7,000,000 in 1918. For 1919, the figure, while lower, was still considerable: 4,000,000 pounds. By comparison, the 500,000 pounds of 1938 and the 300,000 of 1939 look very small, and at that a large proportion of the current catch is used for bait.

It is of interest that the sardine industry owes the inception of its large scale phase to those same efforts to provide war-time substitutes. Sardine landings in 1916 totalled around 15,000,000 pounds, in 1918 over 157,000,000. In contrast to the herring, the sardine catch continued to increase thereafter, with reported landings of about 933,000,000 pounds in 1938 and over 1,160,000,000 in 1939. The reasons for these diverging trends appear to have been two: the herring was incapable of supporting a fishery anywhere near equal in size to the sardine; and the herring was unable to compete successfully with the sardine for the favor of the consumer and of the cannery operator.

Another reminder that our problems are not so new as they seem was George Neale's paper entitled "*Ducks vs. Rice*," a question which has been arousing the concern of Sacramento Valley rice growers the past year. Mr. Neale described the experiments which were carried out to test the efficacy of bombs in keeping the ducks away, and gave instructions in their use. This bombing method still remains one of the best ways of ridding the rice fields of ducks, and is widely used at present.—*Brian Curtis, Editor, California Fish and Game.*

REPORTS

FISH CASES

October, November, December, 1942

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: Undersize, overlimit, out of shell, no license.....	10	\$158 00	
Angling: No license, false statement in securing license, closed season, within 150 ft. of dam, set lines after sundown, two poles.....	21	402 50	
Bass: Undersized, closed season; no license, two lines, overlimit, possess for sale	34	835 00	5
Clams: Out of shell, overlimit, undersize, no license, possess clam fork in Dist. 18A.....	20	355 00	29
Lobster: Closed season.....	1	10 00	
Sunfish: No license.....	1	10 00	
Net: Operating round whole net in Fish and Game District 20, closed district.....	1	100 00	
Using and operating set net in Stanislaus River.....	3	400 00	
Salmon: Possession salmon spears within 300 ft. closed area, shooting salmon, night fishing, overlimit, no license, selling salmon marked not for resale taken from the Klamath River.....	30	585 00	35
Trout: Overlimit, closed area, more than one pole.....	2	50 00	
Pollution.....	12	1,600 00	
Operating purse seine net and taking Bluefin Tuna in closed area.....	31	1,910 00	
Totals.....	166	\$6,415 50	69

GAME CASES

October, November, December, 1942

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope: Closed season.....	2	\$160 00	
Deer: Night hunting, hunting in refuge, taking forked deer in District 1 $\frac{1}{3}$, transfer deer tags, overlimit, closed season, hunting in game refuge, failing to tag deer, taking spiked deer, taking fawn, altering deer tags.....	73	3,532 00	4
Pheasants: Closed season, taking females, no license.....	88	3,883 50	55
Firearms: Discharging firearms in game refuge and shooting from highway.....	11	230 00	
Deer meat: Closed season, female.....	4	350 00	
Doves: Closed season, overlimit, shooting from auto, no license, taking by trap.....	16	325 00	
Hunting: No license, failure to show license, hunting in refuge.....	32	507 00	
Nongame birds.....	10	170 00	
Wild swans.....	2	125 00	
Sagechens.....	2	75 00	
Quail: Closed season, no license.....	8	270 00	
Rabbits: Closed season, no license.....	3	20 00	
Woodducks.....	7	170 00	
Wilson Snipe.....	1	25 00	
Willits.....	1	25 00	
Jacksnipe.....	1	12 50	
Using another's license.....	1	25 00	
Shorebirds.....	5	\$105 00	
Shooting from auto.....	7	145 00	
Shooting ducks from powerboat.....	39	1,590 00	
Ducks: Closed season, early shooting, night hunting, overlimit, after sunset, no license, taking without plug in gun, without duck stamp.....	173	5,116 00	
Taking money for privilege of hunting ducks, no license.....	1	25 00	
Taking fully protected game birds.....	1	25 00	
Taking grey fox, closed season.....	1	10 00	
False statement in procuring license.....	1	25 00	
Possession shotgun capable of holding more than six shells.....	1	10 00	
Possession robins and flickers.....	1	70 00	
Trespassing.....	1	50 00	
Falsifying to secure citizen's license.....	1	200 00	
Totals.....	494	\$17,276 00	59

SEIZURES OF FISH AND GAME

October, November, December, 1942

Fish:

Abalones, Black	12
Abalones, Red	80
Bass, striped	5
Bass, striped, pounds	853
Clams, Pismo	146
Lobster traps	14
Fish spear	1
Salmon net	1
Salmon	95

Game:

Deer	17
Deer meat, pounds	445
Deer meat, canned, jars	12
Doves	112
Pheasant	99
Quail	6
Rabbits, brush	2
Sagehens	4
Woodducks	7
Wilson Snipe	2
Swans	3
Jacksnipe	1
White Crowned Sparrows	5
Ducks	503
Antelope	1
Dee meat, pounds	60

BUREAU OF ENGINEERING

JOHN SPENCER, Chief.....	San Francisco
Clarence Elliger, Assistant Hydraulic Engineer.....	San Francisco
Samuel Kabakov, Junior Civil Engineer.....	San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief.....	Sacramento
R. Nickerson, Supervising License Agent.....	Los Angeles
Emil Dorig, License Agent.....	San Francisco

ACCOUNTS AND DISBURSEMENTS

D. H. BLOOD, Departmental Accounting Officer.....	Sacramento
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BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol (absent on military leave).....	San Francisco
L. F. CHATELLE, Chief of Patrol.....	San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

C. S. Eauder, Inspector in Charge.....	Sacramento
--	------------

Northern Division

A. A. Jordan, Captain.....	Redding
Jos. H. Sanders, Captain.....	Sacramento
A. H. Willard, Captain.....	Rocklin
E. O. Wraith, Captain.....	Chico
L. E. Mercer, Warden, Butte County.....	Chico
Taylor London, Warden, Colusa County.....	Colusa
Albert Sears, Warden, El Dorado County.....	Placerville
E. C. Vail, Warden, Glenn County.....	Willows
Don Davison, Warden, Modoc County.....	Alturas
Earl Hiscox, Warden, Nevada County.....	Nevada City
Nelson Poole, Warden, Placer County.....	Auburn
E. J. Johnson, Warden, Plumas County.....	Quincy
George Shockley, Warden, Plumas County.....	Portola
H. S. Vary, Warden, Sacramento County.....	Sacramento
Charles Sibeck, Warden, Sacramento County.....	Sacramento
Earl Caldwell, Warden, Shasta County.....	Burney
Chas. Love, Warden, Shasta County.....	Redding
Don Chipman, Warden, Siskiyou County.....	Dunsmuir
Brice Hammack, Warden, Siskiyou County.....	Yreka
Louis Olive, Warden, Lassen County.....	Susanville
Fred R. Starr, Warden, Siskiyou County.....	Dorris
R. E. Tutt, Warden, Sierra County.....	Downieville
A. Granstrom, Warden, Sutter County.....	Yuba City
R. W. Anderson, Warden, Tehama County.....	Red Bluff
Harold Erwick, Warden, Tehama County.....	Corning
C. L. Gourley, Warden, Trinity County.....	Weaverville
C. O. Fisher, Warden, Yolo County.....	Woodland
R. A. Tinnin, Warden, Yuba County.....	Marysville

Southern Division

S. R. Gilloon, Captain.....	Fresno
John O'Connell, Captain.....	Stockton
R. J. Little, Warden, Amador County.....	Pine Grove
L. R. Garrett, Warden, Calaveras County.....	Murphys
F. A. Bullard, Warden, Fresno County.....	Reedley
Paul Kehrre, Warden, Fresno County.....	Fresno
Lester Arnold, Warden, Kern County.....	Bakersfield
C. L. Brown, Warden, Kern County.....	Kernville
C. S. Donham, Warden, Kern County.....	Taft
Ray Ellis, Warden, Kings County.....	Hanford
H. E. Black, Warden, Madera County.....	Madera
Gilbert T. Davis, Warden, Mariposa County.....	Mariposa
Hilton Bergstrom, Warden, Merced County.....	Los Banos
H. Groves, Warden, Merced County.....	Merced
R. J. Bullard, Warden, San Joaquin County.....	Tracy
Wm. Hoppe, Warden, San Joaquin County.....	Lodi
Geo. Magladry, Warden, Stanislaus County.....	Modesto
W. I. Long, Warden, Tulare County.....	Visalia
Roswell Welch, Warden, Tulare County.....	Porterville
F. F. Johnston, Warden, Tuolumne County.....	Sonora

COAST DISTRICT (Headquarters, San Francisco)

Wm. J. Harp, Inspector in Charge.....San Francisco

Northern Division

Scott Feland, Captain.....Eureka
 Ray Diamond, Warden, Humboldt County.....Arcata
 W. J. Black, Warden, Humboldt County.....Garberville
 W. F. Kaliber, Warden, Humboldt County.....Fortuna
 Laurence Werder, Warden, Humboldt County.....Eureka
 Kenneth Langford, Warden, Lake County.....Lakeport
 M. F. Joy, Warden, Marin County.....Tiburon
 R. J. Yates, Warden, Marin County.....San Rafael
 Ovid Holmes, Warden, Mendocino County.....Fort Bragg
 Floyd Loots, Warden, Mendocino County.....Willits
 Leo Mitchell, Warden, Mendocino County.....Point Arena
 J. W. Harbuck, Warden, Napa County.....Napa
 Bert Laws, Warden, Sonoma County.....Petaluma
 Victor Von Arx, Warden, Sonoma County.....Santa Rosa
 Jack Sawyer, Warden, Sonoma County.....Cloverdale

Southern Division

O. P. Brownlow, Captain.....Alameda
 C. L. Bundoek, Warden, Alameda County.....Oakland
 Ed Clements, Warden, Contra Costa County.....Martinez
 Owen Mello, Warden, Monterey County.....Pacific Grove
 Henry Ocker, Warden, Monterey County.....King City
 F. H. Post, Warden, Monterey County.....Salinas
 J. P. Vissiere, Warden, San Benito County.....Hollister
 Lee C. Shea, Warden, San Francisco County.....San Francisco
 C. R. Peek, Warden, San Mateo County.....San Mateo
 M. S. Clark, Warden, Santa Clara County.....Palo Alto
 C. E. Holladay, Warden, Santa Clara County.....San Jose
 F. J. McDermott, Warden, Santa Cruz County.....Santa Cruz
 J. E. Hughes, Warden, Solano County.....Dixon
 R. C. O'Connor, Warden, San Francisco County.....San Francisco

SOUTHERN DISTRICT (Headquarters, Los Angeles)

Earl Macklin, Captain in Charge.....Los Angeles
 E. H. Ober, Captain, Special Duty.....Los Angeles
 F. W. Hecker, Captain.....San Luis Obispo

Western Division

L. T. Ward, Captain.....Escondido
 Fred Albrecht, Warden, Los Angeles County.....Los Angeles
 Walter Emerick, Warden, Los Angeles County.....Palmdale
 Theodore Jolley, Warden, Orange County.....Orange
 E. H. Glidden, Warden, San Diego County.....San Diego
 Chester Parker, Warden, San Diego County.....Julian
 R. E. Bedwell, Warden, Santa Barbara County.....Santa Barbara
 W. Greenwald, Warden, Ventura County.....Fillmore
 Orben Philbrick, Warden, San Luis Obispo County.....Paso Robles

Eastern Division

H. C. Jackson, Captain.....San Bernardino
 C. J. Walters, Warden, Inyo County.....Independence
 James Loundagin, Warden, Mono County.....Bishop
 W. C. Blewett, Warden, Riverside County.....Indio
 W. L. Hare, Warden, Riverside County.....Elsinore
 W. C. Malone, Warden, San Bernardino County.....San Bernardino
 Erol Greenleaf, Warden, San Bernardino County.....Big Bear Lake
 Otto Rowland, Warden, San Bernardino County.....Victorville

MARINE PATROL

Ralph Classic, Captain.....	Monterey
Lars Weseth, Master, M.V. <i>N. B. Scofield</i>	Terminal Island
Kenneth Webb, Warden.....	San Diego
Kenneth Hooker, Warden, Cruiser <i>Rainbow III</i>	San Rafael
Otis Wright, Assistant Warden.....	Monterey
Walter Engelke, Captain and Warden, Cruiser <i>Bonito</i>	Santa Monica
Robert Mills.....	Santa Barbara
Ellis Berry, Warden.....	Monterey
J. R. Cox, Warden.....	Watsonville
N. C. Kunkel, Warden.....	Terminal Island
Leslie E. Lahr, Warden.....	Terminal Island
Ralph Miller, Warden.....	San Francisco
Tate F. Miller, Warden.....	Terminal Island
T. W. Schilling, Warden.....	Terminal Island
G. R. Smalley, Warden.....	Richmond
T. J. Smith, Warden.....	San Diego
L. G. Van Vorhis, Warden.....	Terminal Island
E. L. Walker, Warden.....	Terminal Island
Frank Felton, Assistant Warden.....	San Diego

POLLUTION DETAIL

Paul A. Shaw, Chemical Engineer.....	San Francisco
Don Hall, Warden.....	Oakland
H. L. Lantis, Warden.....	Long Beach
R. L. Schoen, Warden.....	Wilmington
Walter R. Krukow, Assistant Warden.....	Santa Barbara
J. A. Reutgen, Assistant Warden.....	Martinez

MARINE PATROL AND RESEARCH BOATS

Cruiser *Bonito*, Newport Harbor

Cruiser *Rainbow III*, San Rafael

Launch *Shrapnel*, Suisun



